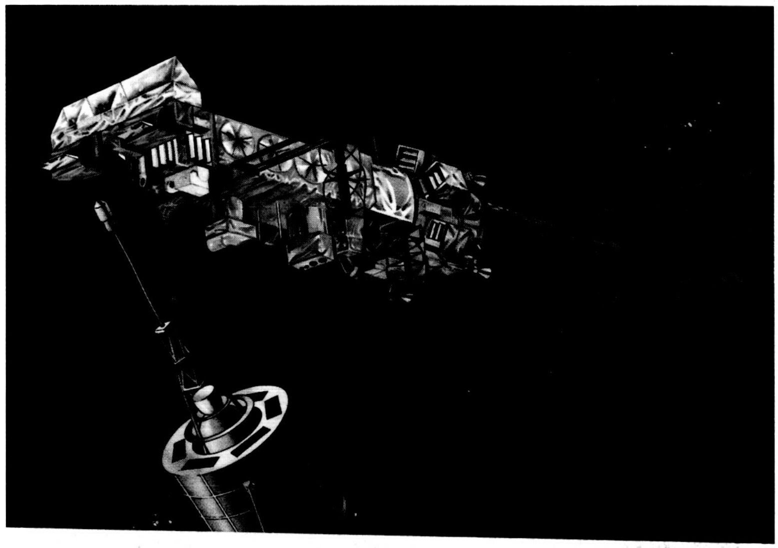
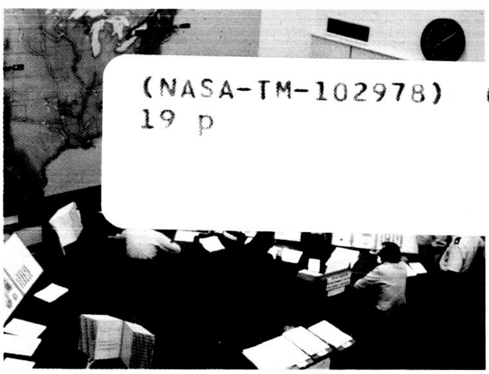
GSFC

COSPAS/SARSAT





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Satellites Save Lives

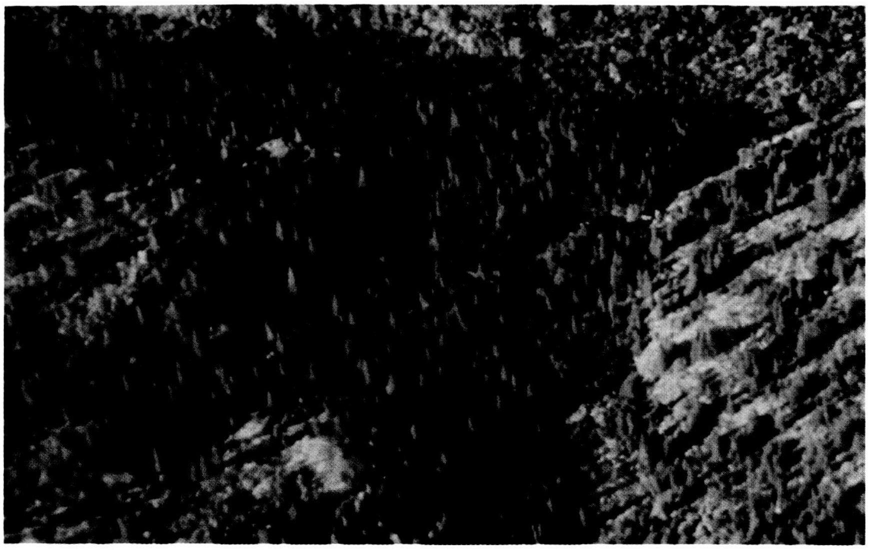
The antennas of the COSPAS/SARSAT satellites are aimed toward the Earth to detect signals of distress. The signals are transmitted to space from downed airplanes, capsized boats, and other emergency situations. The COSPAS/SARSAT system aids worldwide rescue centers in locating the sources of the signals to speed search and rescue efforts.

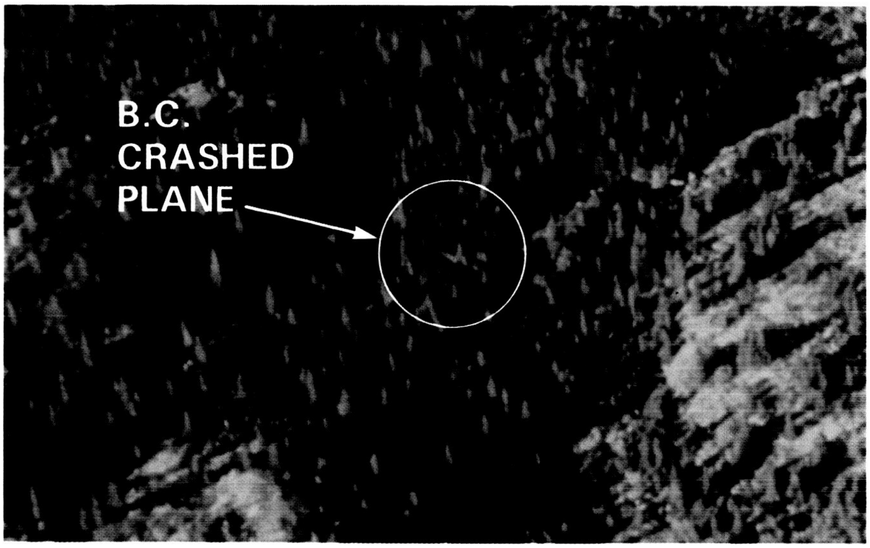
COSPAS (a Russian abbreviation of Space System for Search of Vessels in Distress) and SARSAT (Search and Rescue Satellite-Aided Tracking System) represent a model program of international cooperation. The United States, Canada, France (SARSAT), and the Soviet Union (COSPAS) are the founders of the program. As of mid 1986, other participating countries are Bulgaria, Denmark, Finland, Norway, and the United Kingdom. Additional countries (e.g., Brazil) are involved in negotiations for their participation.

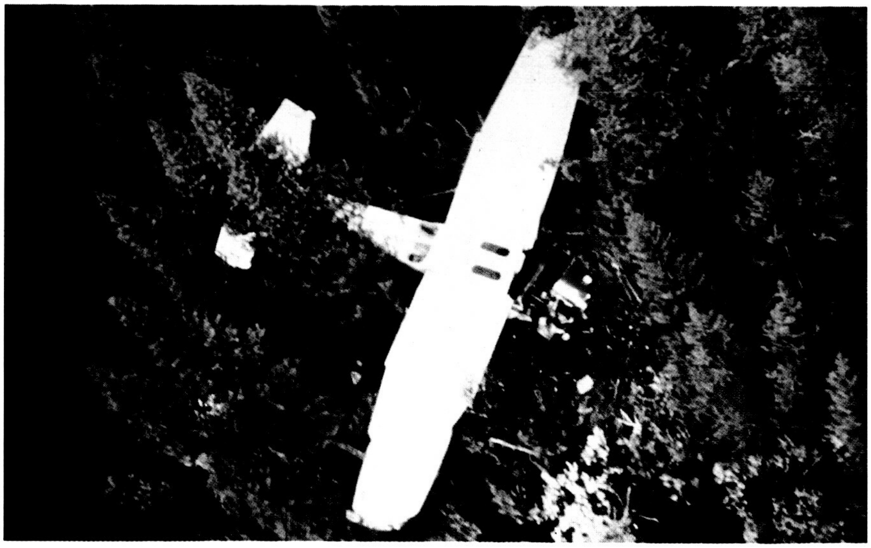
Since COSPAS/SARSAT program inception, the National Aeronautics and Space Administration (NASA) has provided ongoing research and development to create space and ground systems. NASA has collaborated closely with the U.S. Air Force, the U.S. Coast Guard, and the National Oceanic and Atmospheric Administration (NOAA) from the early phases through the ongoing enhancement activities. NOAA directs the current operational system within the United States. The U.S. Air Force, the U.S. Coast Guard, and their respective auxiliary organizations are performing the actual search and rescue tasks. The U.S. Air Force serves as the central communications point for the United States search and rescue activities and as a link to the international community.

COSPAS/SARSAT is divided into two systems to detect emergency beacons. The first system broadcasts on the 121.5/243 MHz frequencies and works with Emergency Locator Transmitters (ELTs) and Emergency Position Indicating Radio Beacons (EPIRBs) at those frequencies. This system is limited to a circular area within a 3,220 km (2,000 miles) radius of a ground station. A new system on the 406 MHz frequency provides monitoring for the entire Earth.

In the first 3 years of the program, COSPAS/SARSAT has been instrumental in saving over 500 lives. In the future, the expansion of COSPAS/SARSAT will provide increasingly accurate locations worldwide, improve distress detection, and provide enhanced data handling to help speed up life-saving activities.







Dramatic Rescues

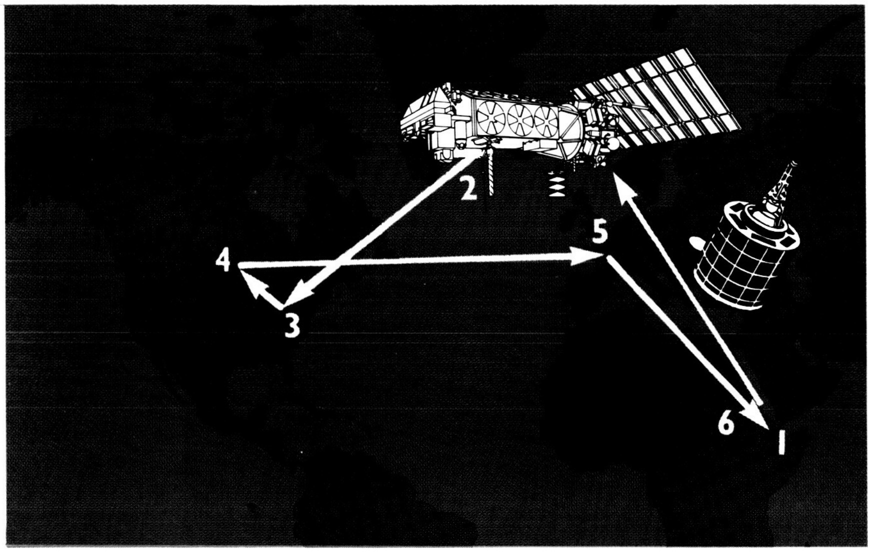
The First Rescue

The would-be rescuers had been looking for the young couple. The couple's plane went down in British Columbia 2 months earlier in July 1982 and was never found. The Canadian government mounted an extensive search, costing almost $2 million before it was stopped. The young man's father did not give up hope. The father, a pilot, and a friend had embarked on their own airborne search and rescue mission.

During the search, their plane had crashed and they were injured and stranded in the midst of 50 foot trees and 7,000 foot mountains. The Victoria Rescue Coordination Center (RCC) in Canada received a report that the plane was missing in British Columbia. The crashed Cessna 172 was inoperable, but the occupants were alive and the ELT was working. It was broadcasting emergency signals up and out into space.

Canada had just become an international partner in a new space-based search and rescue network. The RCC contacted the network's ground station in Ottawa. As the Soviet COSPAS I satellite passed over the Cessna crash site, it detected the emergency beacon and repeated the data to the Trenton Ontario Air Rescue Station. The crash location was determined and the RCC sent a search aircraft. The location was within 22.5 km (13.9 miles) of the crash site. The father, pilot, and friend became the first individuals to be rescued with the aid of a satellite.

If only the COSPAS/SARSAT system had been available for the first crash, search risks and costs would have been reduced and the couple's lives might have been spared.



Global 406 System Rescue

An unlikely turn of events . . . until the COSPAS/SARSAT 406 MHz system was created.

A Belgian race car driver and his codriver were racing through Somalia, Africa in their Citroen. The competition was to take them a total of 30 weeks from Cape Town to their goal of Tierra del Fuego at the tip of South America. They were to drive through Africa to Saudi Arabia, India, and China; by boat from Tokyo to Canada; drive through the Western United States, Mexico, South America, and into Argentina. The race was a chance of a lifetime.

On New Year's Eve, anticipation turned into fright as the car crashed and rolled over and over. The driver was thrown from the car and his skull was fractured. In the midst of remote Africa, there was neither a phone nor medical help. The codriver flipped on an experimental transmitter to start broadcasting its 406 MHz emergency beacon into space. Someone, somewhere, might hear the call for help.

The 406 MHz frequency, still in the experimental stage, allowed global reception of data that was unobtainable with the old system. The signal was first detected by SARSAT. The 406 MHz signal was stored in SARSAT and "dumped" at the next U.S. ground station that came into view. The U.S. Air Force notified the French government, whose diplomats in Africa arranged for a doctor to be flown to the injured driver. The driver was then evacuated to a hospital in Belgium where he recovered and later rejoined the race.

Rescue At Sea

The three men left from Portland, Maine for England on October 9, 1982 in their trimaran GONZO. When they had traveled about 480 km (300 miles) southeast of Cape Cod, they encountered 20 foot waves with wind conditions of 30 to 50 knots. The GONZO capsized on October 10 but the three men survived. They were well prepared with survival suits and emergency gear, including their EPIRB. One of the crew activated the EPIRB to signal for help.

A commercial airliner flying from New York to Madrid picked up the EPIRB signal and notified the Federal Aviation Administration (FAA) New York Oceanic Center. The FAA alerted the Coast Guard in New York, who, in turn, called the Mission Control Center (MCC) for COSPAS/SARSAT location assistance.

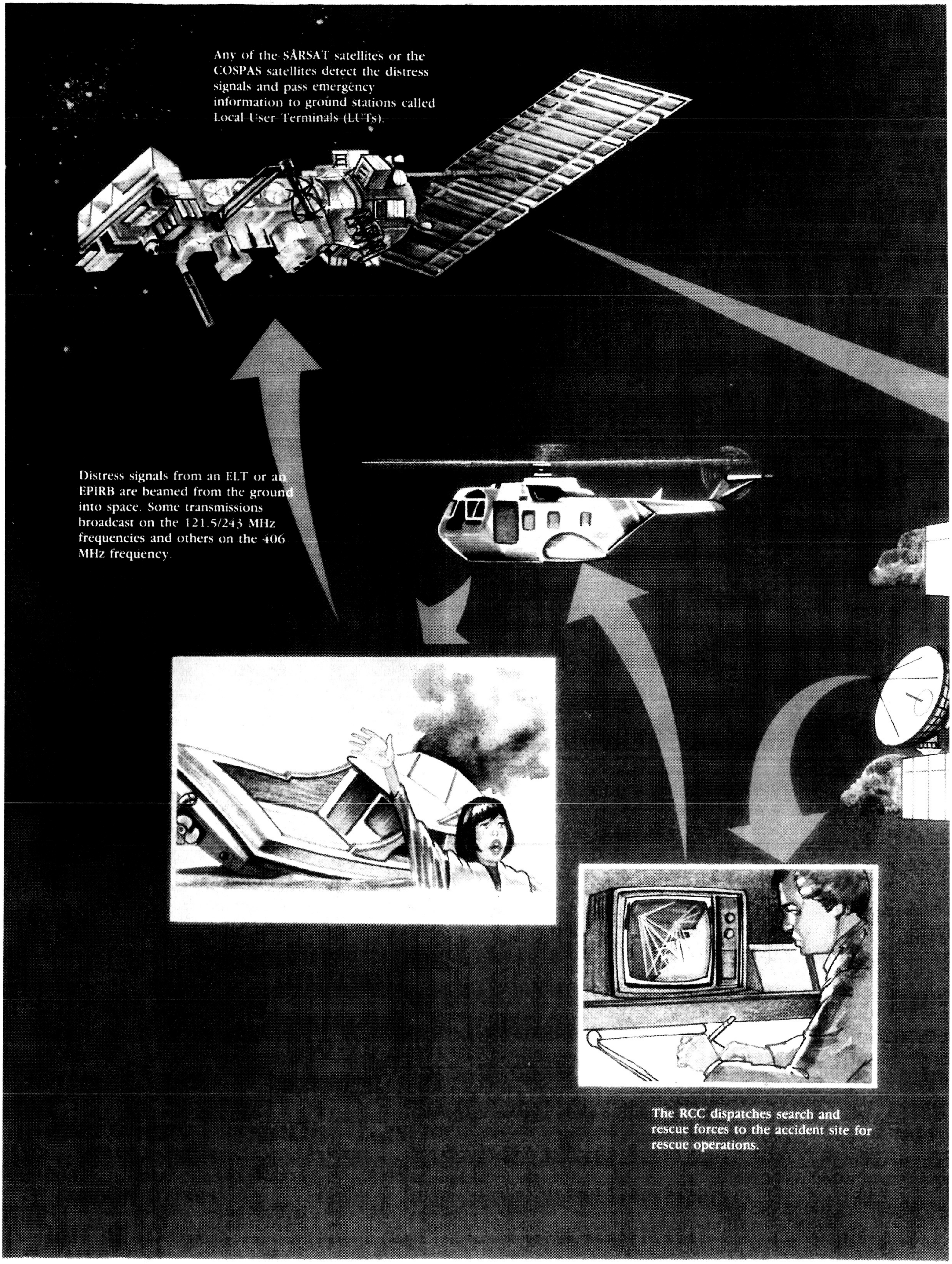
An HC-130 helicopter was dispatched from Elizabeth City, New Jersey to investigate. Based on the COSPAS/SARSAT location information, the HC-130 spotted the GONZO emergency flare. The Coast Guard *Vigorous* and the merchant vessel *California Getty* were diverted to the scene. Despite heavy seas, the *Vigorous*, with some assistance from the *Getty*, was able to recover the survivors.

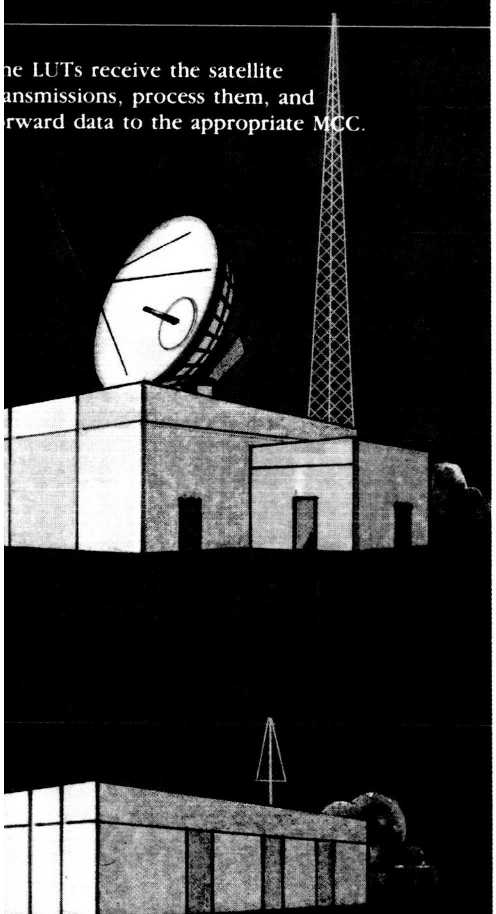
All In A Day's Work

Two Canadians in a Cessna 182 crashed to the snow-covered ground after having fought strong downdrafts in Glacier National Park. The plane flipped over. They found themselves hanging upside down with minimal cuts and bruises. After taking stock of the survival supplies onboard, they found that they had coveralls, a down sleeping bag, a parka, an orange tarp, and minimum rations.

The mountain snows of October 1985 had come early. It was cold. As they waited, the ELT was beaming its emergency message. COSPAS and SARSAT both picked up the distress signals. The wreckage was pinpointed to within 16 km (10 miles). The USMCC at Scott Air Force Base in Illinois notified the Montana Aeronautics Division to coordinate the search and rescue effort. The rescue plane flew out at daybreak.

The victims realized that their crashed plane was partially obscured by the snow and they watched as the rescue plane circled overhead. They sent a rescue signal by waving their orange tarp. The rescue helicopter followed shortly thereafter to transport the victims to medical care . . . and within only 18 hours from the time of the crash.


Any of the SARSAT satellites or the COSPAS satellites detect the distress signals and pass emergency information to ground stations called Local User Terminals (LUTs).
Distress signals from an ELT or an EPIRB are beamed from the ground into space. Some transmissions broadcast on the 121.5/243 MHz frequencies and others on the 406 MHz frequency.
The RCC dispatches search and rescue forces to the accident site for rescue operations.



ne LUTs receive the satellite
ansmissions, process them, and
rward data to the appropriate MCC.

he MCC collects the data received
om the LUTs and forwards the data
the RCC closest to the accident
te or to a MCC in another country.

What Is the System?

As soon as the first satellites were placed into Earth orbit during the late 1950's, the concept for a satellite-aided search and rescue project began to take shape. NASA began to experiment with "random-access Doppler tracking" on the Nimbus satellite series in the 1970's. These experiments served to locate and verify transmissions from remote terrestrial sensors (weather stations, buoys, drifting balloons, and other platforms). The first operational random-access Doppler system was the French ARGOS on the NOAA TIROS satellite series. The 406 MHz search and rescue system has evolved from this ARGOS system.

The COSPAS/SARSAT program became an international effort in 1976 with the United States, Canada, and France discussing the possibilities of satellite-aided search and rescue. Joint SARSAT testing agreements in 1979 stated that the United States would supply the satellites, Canada would supply the space-borne repeaters for all frequencies, and France would supply space-borne processors for the 406 MHz frequency. The Soviet Union joined the program in 1980, agreeing to equip their COSMOS satellites with COSPAS repeaters and processors. Norway added their participation in 1981, representing Sweden as well.

The year 1982 marked the beginning of the COSPAS/SARSAT experimental operations. The first COSPAS launch took place and the initial operations of four North American ground stations began. The first satellite-aided rescue occurred not long after that launch. The United Kingdom joined the program. The first SARSAT satellite was launched in 1983.

By 1984, the system had a constellation of two COSPAS and two SARSAT satellites and operationally used the 121.5/243 MHz frequencies. Bulgaria and Finland joined the program. At this point, NASA turned over the United States SARSAT leadership to NOAA, the agency responsible for operational U.S. civilian satellites. NASA continued its leadership role in the areas of research and development.

The operational use of the 406 MHz system, designed for global coverage by satellite, was initiated in 1985. The ground system is undergoing continual expansion of its data analysis and distribution capabilities.

Emergency Transmitters

The transmitters are the links from the point of emergency to the point of rescue. The transmitters are built to survive crashes, hazardous terrain, and extreme weather. They are designed to send emergency alerts and provide location information through satellite measurements. Signals sent on the 121.5/243 MHz frequencies allow for location determination within 20 km (12 miles) of the transmission site; signals sent on the 406 MHz frequency allow for location determination within 5 km (3.1 miles) of the transmission site. The ability to locate the precise signal point of origin will improve even more as the transmitter technology and operational efficiency evolve over the next few years.

Emergency Locator Transmitter (ELT)

The ELT became a vital component of United States general aviation aircraft in the early 1970's under congressional mandate. Upon impact, the automatic activation of an emergency radio beam alerted aircraft flying overhead. This marked the initiation of emergency search and rescue activities. Frequently, however, no airplane was overhead and the signal was not heard. The need for an ever-present listening and positioning system became apparent. Consequently, the COSPAS/SARSAT satellite system was developed to monitor the ELT transmissions. The system was designed to alert the ground stations in the event of an ELT signal and to provide location information (not obtainable via overflying aircraft). Today, more than 250,000 ELTs are in operation by private and commercial aircraft in the United States.

Different types of ELTs are now being used, but all transmitters include a stable frequency source, modulators, radio frequency amplifiers, and batteries. An omni-directional antenna, crash activation sensors, on/off/reset switch, cables, and mounting hardware are standard equipment. During operation, the batteries will last between 24 and 48 hours at minus 20 degrees Fahrenheit or lower.

The first ELTs broadcast a characteristic audio signal on 121.5 MHz and 243 MHz frequencies. Although these transmitters had been designed for interaction with airplanes, they could also be used with satellites. Later, a more sophisticated ELT transmitting at 406 MHz was designed specifically for satellite interaction.

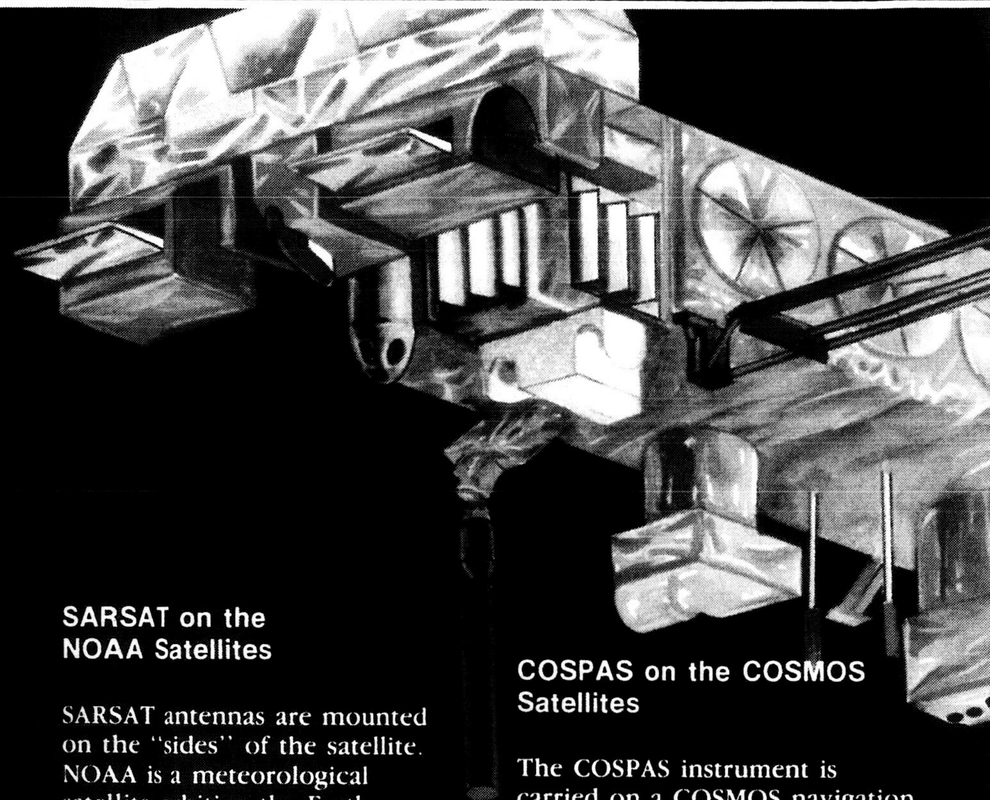
Use of the 406 MHz system will enhance the ability of the COSPAS/SARSAT to locate the position of the distress site. The 406 MHz beacon contains a message format that provides identification data, nationality, type of user, and sometimes, the type of emergency.

Emergency Position Indicating Radio Beacon (EPIRB)

Known as the "floating beacon," the EPIRBs are employed by over 7,000 commercial or private marine vessels that venture into open seas. The greatest expansion in usage of COSPAS/SARSAT is expected from the EPIRB users. Weather related dangers and accidents, mechanical disabilities, or medical help requirements are among common marine emergency situations.

EPIRBs operate on the same frequencies and have the same signal characteristics as ELTs. The EPIRBs transmitting on the 406 MHz frequency will sometimes include within the message the "instant position listing" from the vessel's latest update. The EPIRB is self-activated by contact with water or it can be activated manually. The EPIRB is waterproof and it floats. During operation, the batteries will last between 24 and 48 hours at 20 degrees Fahrenheit or lower.


UNITED STATES
FRANCE
CANADA
SEARCH AND RESCUE SATELLITE AIDED TRACKING
SARSAT



Space Segment

COSPAS/SARSAT satellites maintain a constant space-based vigil. Their instruments are designed to receive the distress signals from Earth. The receivers are carried on satellites that have been actually designed for other purposes, such as meteorology and navigation. These satellites move in near-polar orbits, permitting worldwide coverage as the Earth rotates. Currently, COSPAS/SARSAT instruments are carried on the Soviet Union COSMOS satellite series and the United States NOAA (Advanced TIROS) satellite series.

The ELT and EPIRB 121.5/243 and 406 MHz emergency signals are received by the satellite instruments. A determination is made of the distress signal frequency "Doppler shift" caused by the motion of the spacecraft in relation to the beacon. This shift provides a measurement for computation of the emergency location. The distress location alerts are then relayed from the spacecraft to the LUTs and, hence, to the MCCs (discussed in "Ground Segment"). With four operational satellites in orbit, the time until contact between an individual in an emergency situation and a satellite varies from a few minutes to a few hours.

SARSAT on the NOAA Satellites

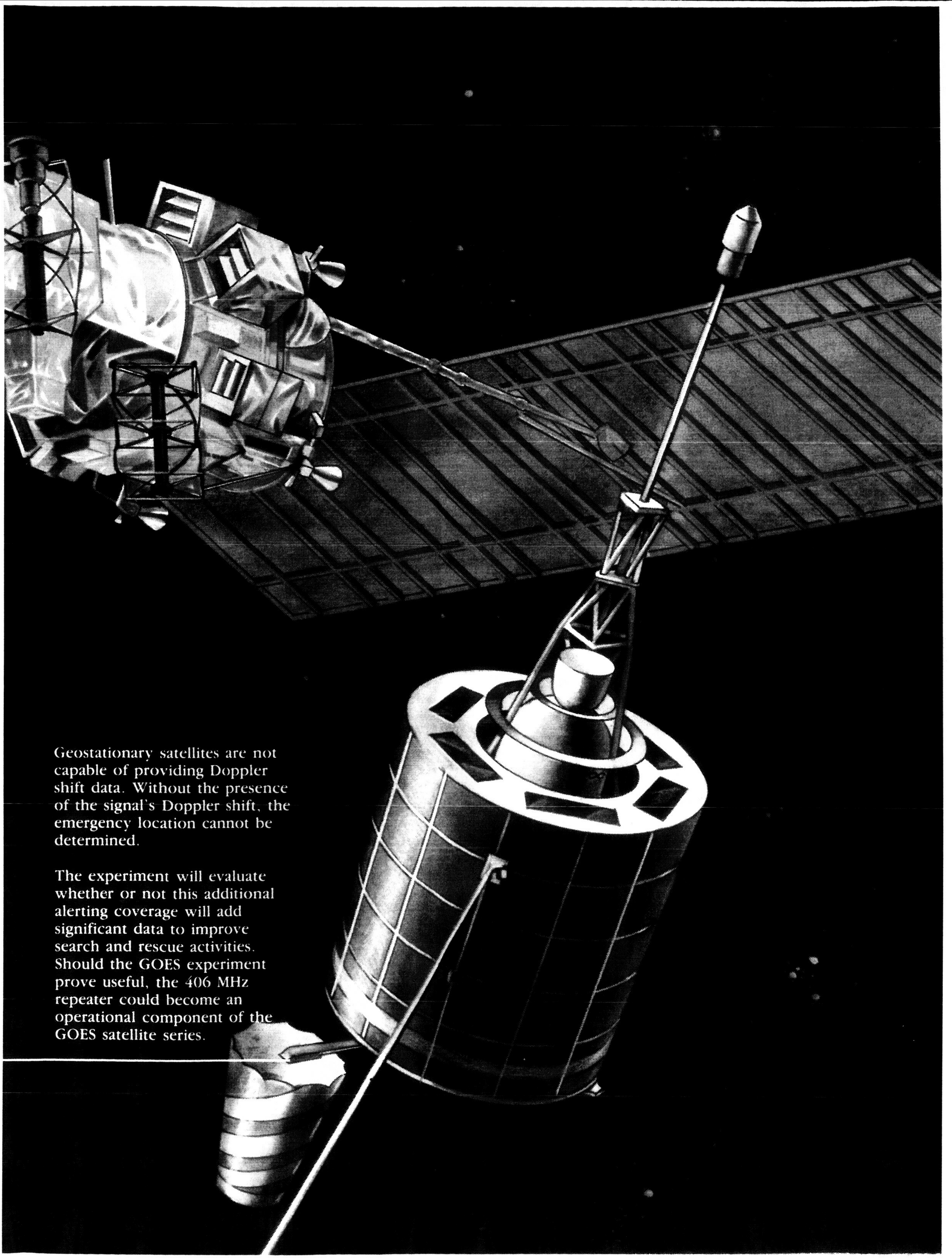
SARSAT antennas are mounted on the "sides" of the satellite. NOAA is a meteorological satellite orbiting the Earth approximately every 100 minutes at an altitude of about 850 km (528 miles), inclined 99 degrees relative to the Equator. Two NOAA satellites are maintained in orbit at all times. The search and rescue repeater receives the 121.5/243 MHz distress signals and retransmits them in "real time" (immediately) over 1544.5 MHz (L-band) to the LUTs. For a 406 MHz transmission, the search and rescue processor captures identification and other beacon information carried on the 406 MHz signal and provides measurements of the Doppler frequency and time. Also, onboard memories store the 406 MHz data for later transmission in case the signals that are sent in real time are not in range of a ground station. This actually provides global coverage. The repeaters for this system have been developed by the Canadian Department of Communications. The processors have been developed by the French Centre National D'Etudes Spatiales.

COSPAS on the COSMOS Satellites

The COSPAS instrument is carried on a COSMOS navigation satellite orbiting the Earth approximately every 105 minutes at an altitude of about 999 km (620 miles), inclined 83 degrees relative to the Equator. Two satellites are maintained in orbit at all times. The search and rescue repeater receives and retransmits the 121.5 MHz signals. Onboard memories store the processed 406 MHz data for later transmission to the ground station at the same time that signals are sent in real time. The COSPAS and SARSAT satellites provide identical services for the 121.5 and 406 MHz signals.

NASA Geostationary Experiment

Currently, NASA is determining the usefulness of detecting the 406 MHz beacons from a geostationary orbital position. The geostationary satellite (GOES-H to be launched in 1986) will offer continuous coverage to provide immediate detection of 406 MHz distress beacons.



Geostationary satellites are not capable of providing Doppler shift data. Without the presence of the signal's Doppler shift, the emergency location cannot be determined.

The experiment will evaluate whether or not this additional alerting coverage will add significant data to improve search and rescue activities. Should the GOES experiment prove useful, the 406 MHz repeater could become an operational component of the GOES satellite series.

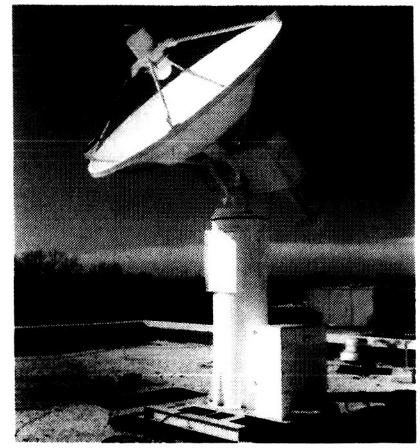
Ground Segment

Cooperation between organizations and countries fosters the success of the COSPAS/SARSAT mission. Both SARSAT and COSPAS systems are compatible with each other. Life saving messages cross the international telecommunications network, regardless of political boundaries when lives are in the balance.

The COSPAS/SARSAT ground segment is an intricate support network that is continually expanding to increase system efficiency. In the future, many countries will have LUTs and MCCs to receive and process data. Other participants will have facilities to receive data from MCCs to distribute to their own RCCs. A network of Regional Data Distribution Centers (RDDCs) is being developed for the efficient distribution of global distress data that are received via satellite.

Local User Terminals (LUTs)

That LUTs are the ground stations that receive the distress signals from the satellites. In the United States, the ground-based equipment consists of an



antenna to receive the unprocessed, real-time data at the 121.5/243 MHz frequencies and preprocessed, real-time, and stored data at the 406 MHz frequency downlinked from a satellite on L-band (1544.5 MHz). The position of the beacon is determined from this information. Processing time for the information is a matter of minutes and then the signal alert and location information are sent to the MCC. It is expected that by 1987, there will be a total of 13 LUTs, with 3 in the United States, 3 in Canada, 1 in France, 4 in the Soviet Union, 1 in the United Kingdom, 1 in Norway, and 1 in Brazil.

Mission Control Centers (MCCs)

The MCCs collect and edit information from the LUTs and forward the data to the appropriate RCC. If the emergency is located in another country, the appropriate international MCC is notified.

As of early 1986, MCCs were located in the United States, Canada, France, the Soviet Union, Norway, and the United Kingdom. Specific duties vary slightly in each country. The MCCs in the United States and the Soviet Union maintain and distribute satellite orbit and status information.

The USMCC is located at Scott Air Force Base in Illinois. In the future, NOAA will be assuming responsibility for the operation of the USMCC, which will then be located at Suitland, Maryland. The USMCC receives ELT/EPIRB data from LUTs or international MCCs. Data relevant to maritime distress situations are geographically sorted and distributed to the 11 U.S. Coast Guard RCCs. Data relevant to inland downed airplane situations are sorted geographically and transmitted to the U.S. Air Force RCC (at Scott Air Force Base) and to the Alaska Air Command RCC (at Elmendorf Air Force Base). With an international emergency, the USMCC and the MCCs of other nations share information via commercial communication lines.

Rescue Coordination Centers (RCCs)

COSPAS/SARSAT provides early alerts and valuable location information to RCCs that are in charge of actual rescues. The type of rescue effort varies according to the needs of the particular national geography and available resources. In the United States, the U.S. Air Force coordinates inland airplane location and rescue attempts. The U.S. Air Force frequently works through its volunteer auxiliary

organization, the Civil Air Patrol. The U.S. Coast Guard responds to maritime incidents that happen within 320 km (200 miles) of the United States coastline. From that point on, the U.S. Air Force continues the search.

Effective coordination, communication, and controls ensure that every possible effort is made on the part of search and rescue forces to locate each emergency in a timely and accurate manner. The precise locations provided by COSPAS/SARSAT help reduce the hours spent in search and rescue attempts that often occur in situations very hazardous to the rescuers.

Successes/ Improvements

Saves and Assists

As of May 1986, COSPAS/SARSAT has provided distress locations aiding in the rescue of:

- **244 persons rescued in maritime incidents**
- **311 persons rescued in aircraft incidents**
- **22 persons rescued in terrestrial incidents**

The total number of persons rescued as of May 1986 using COSPAS/SARSAT locations is 577.

False Alarms

The COSPAS/SARSAT program is now directing its efforts toward a smooth transition into the next decade. One area requiring improvement is the COSPAS/SARSAT "false alarm rate." A COSPAS/SARSAT false alarm is a signal received from an ELT or EPIRB beacon transmitting in a nondistress situation. False alarms are caused by unintentional activation of the beacon through improper handling; equipment failure; or incorrect mounting, disposal, testing, or shipment.

The performance of the present COSPAS/SARSAT system is directly affected by the time that the rescue forces must spend in tracking down false alarms. Each distress signal must be tracked down—whether it is an actual emergency or a false alarm. No other method of validation is possible. When a false alarm beacon is located, it is turned off. Many times, a real distress beacon then can be heard and located. The 121.5/243 MHz false alarm rate is very high, hampering the timely location of victims by diverting search resources. False alarms interfere with individuals using the 121.5/243 MHz frequencies for emergencies. False alarms waste expensive resources required to search for real distresses.

Present solutions under examination are:

1. Enforce laws governing the use of emergency frequencies.

2. Implement redesigned ELTs and EPIRBs, including revised testing procedures and regulations.

3. Educate pilots and mariners to:

   — Add an ELT/EPIRB check to all "shut-down" procedures lists.

   — Monitor the 121.5/243 MHz channel before leaving the craft to ensure that the ELT/EPIRB is not transmitting a signal.

   — Limit the time duration of tests to only a few seconds at authorized times.

   — Avoid unnecessary use of the emergency channel for voice transmissions.

   — Remove the battery before storage, shipment, or disposal of an ELT or EPIRB. All ELTs and EPIRBs have the potential for sending a false alarm. Removal of the batteries eliminates this potential.

Expanding Into the Future

NASA is a leader in the development of space and ground systems technology, which are operated for the benefit of all. Some examples are communications by satellite, weather and environmental monitoring by satellite, remote scientific data collection by satellite, and now, search and rescue by satellite. Research and development that began around 1970 at NASA/Goddard Space Flight Center, together with research performed by Canada, France, and the Soviet Union, led to the COSPAS/SARSAT satellite system. The U.S. Air Force, U.S. Coast Guard, U.S. contractors for NASA, other U.S. agencies, and international scientific and industrial concerns were vital to the implementation of the system.

NASA recognizes that emerging technologies have a great potential to aid the search and rescue activities of the future. Therefore, NASA is presently engaged in research and development efforts to help shape this future.

These efforts are expected to provide:

— Reduced cost 406 MHz beacons.

— The feasibility for two-way communication links between ELTs/EPIRBs, satellites, and ground systems.

— New methods of distress detection and location.

— Faster and even more accurate locations of distress beacons.

— New satellite methods to support ongoing rescues with information on the distress environment.

New technological developments currently foreseen are the use of the Space Station and polar orbiting platform technology, new remote sensing capabilities, advanced communications, artificial intelligence, and laser communications. These developments portend exciting space-supported additions to the future of search and rescue efforts.

For Additional Information

In the United States, information on the various aspects of the COSPAS/SARSAT system can be obtained from:

General Information:	Office of Public Affairs Code 130 NASA/Goddard Space Flight Center Greenbelt, MD 20771
Research and Development History and Future:	NASA SAR Mission Manager METSAT Project, Code 480 Flight Projects Directorate NASA/Goddard Space Flight Center Greenbelt, MD 20771
General Operational System and Future USMCC:	NOAA National Environmental Satellite, Data, and Information Service SARSAT Program Manager Suitland Federal Center Washington, D.C. 20233

Glossary

ARGOS	French random access Doppler data collection system on NOAA satellites
COSPAS	Space System for Search of Vessels in Distress (Translation from Russian)
ELT	Emergency Locator Transmitter
EPIRB	Emergency Position Indicating Radio Beacon
FAA	Federal Aviation Administration
GOES	Geostationary Operational Environmental Satellite
km	Kilometer
LUT	Local User Terminal (Ground Station)
MCC	Mission Control Center
MHz	Mega-Hertz (10^6 Hertz)
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration Also, NOAA series of satellites
RCC	Rescue Coordination Center
RDDC	Regional Data Distribution Center
SARSAT	Search and Rescue Satellite-Aided Tracking System
TIROS	Television/Infrared Observation Satellite
USMCC	United States Mission Control Center

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National Aeronautics and
Space Administration

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